



TEST REPORT OF
SELECTED PORTIONS OF FCC CFR47 PART 15 SUBPART G
FOR
TV BAND DEVICE PROTOTYPE

MODEL NUMBER: CRS1

REPORT NUMBER: 11U13701-1, Revision A

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Prepared for
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Revision History

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Adaptrum
25 E. Trimble Road
San Jose, CA 95131

EUT DESCRIPTION: TV Band Device Prototype

MODEL: CRS1

SERIAL NUMBER: U0004

DATE TESTED: FEBRUARY 22, 2011

| APPLICABLE STANDARDS | |
|---|--------------|
| STANDARD | TEST RESULTS |
| Selected portions of CFR 47 Part 15 Subpart G | Pass |

Compliance Certification Services (UL CCS) tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL CCS based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL CCS and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL CCS will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For UL CCS By:



MICHAEL HECKROTTE
DIRECTOR OF ENGINEERING
UL CCS

2. PURPOSE AND TEST METHODOLOGY

The emissions mask requirement of FCC CFR 47 Part 15 subpart G requires the maximum performance from available test equipment. The tests documented in this report were performed in order to develop suitable procedures for measuring this parameter. To this end particular care was taken to set the optimum level at the input of the spectrum analyzer.

The remaining portions of the tests were made in accordance with FCC CFR 47 Part 15.709 using well documented FCC procedures.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

UL CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://www.ccsemc.com>.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamplifier Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

| PARAMETER | UNCERTAINTY |
|---------------------------------------|-------------|
| Conducted Disturbance, 0.15 to 30 MHz | 3.52 dB |
| Radiated Disturbance, 30 to 1000 MHz | 4.94 dB |

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is a TV Band Device Prototype.

6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

| TEST EQUIPMENT LIST | | | | | |
|--------------------------------|--------------|--------|--------|------------|-----------|
| Description | Manufacturer | Model | Asset | Cal Date | Cal Due |
| Vector signal generator, 20GHz | Agilent / HP | E8267C | C01066 | 11/12/2010 | 2/12/2012 |
| Spectrum Analyzer, 44 GHz | Agilent / HP | E4446A | C01178 | 8/30/2010 | 8/30/2011 |
| Power Meter | Agilent / HP | 437B | N02778 | 8/11/2010 | 8/11/2012 |
| Power Sensor, 18 GHz | Agilent / HP | 8481A | N02784 | 10/28/2009 | 7/28/2011 |

7. RESULTS

7.1. 99% BANDWIDTH

LIMITS

None, for reporting purposes only.

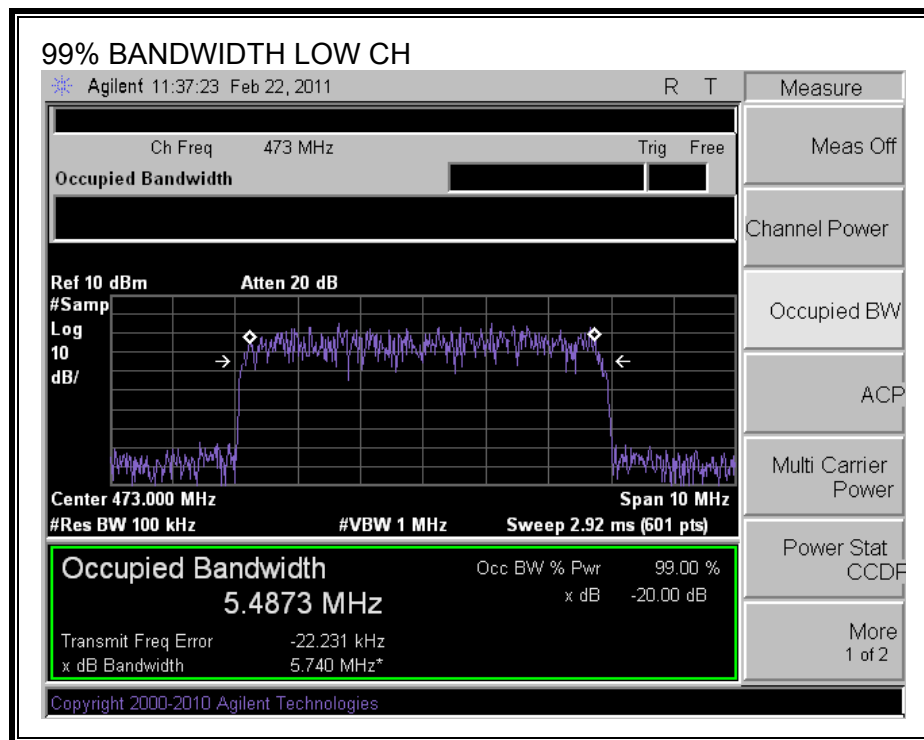
TEST PROCEDURE

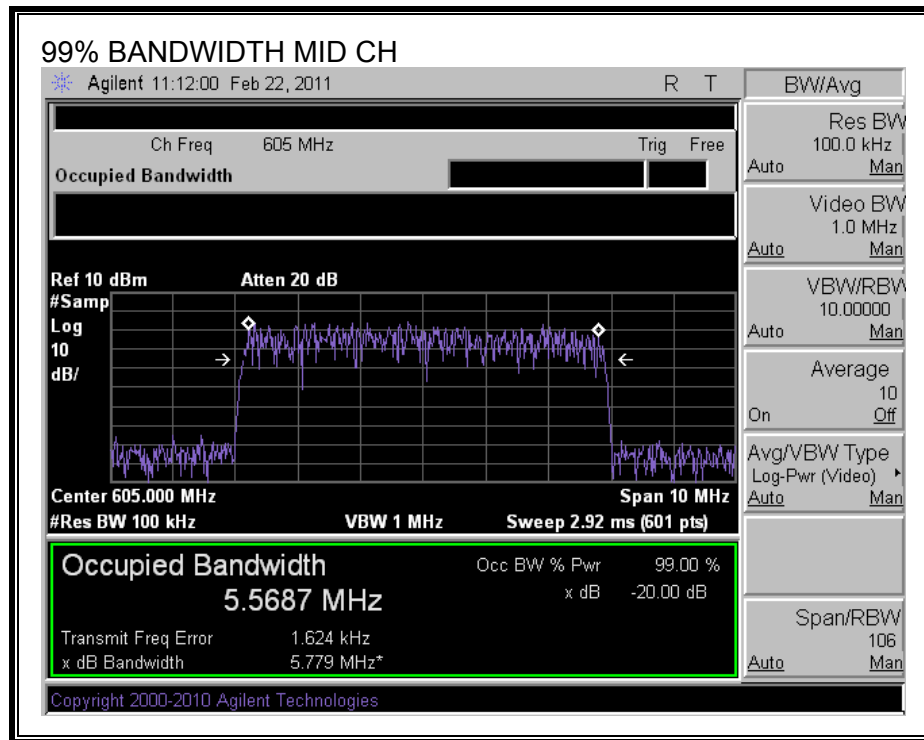
The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

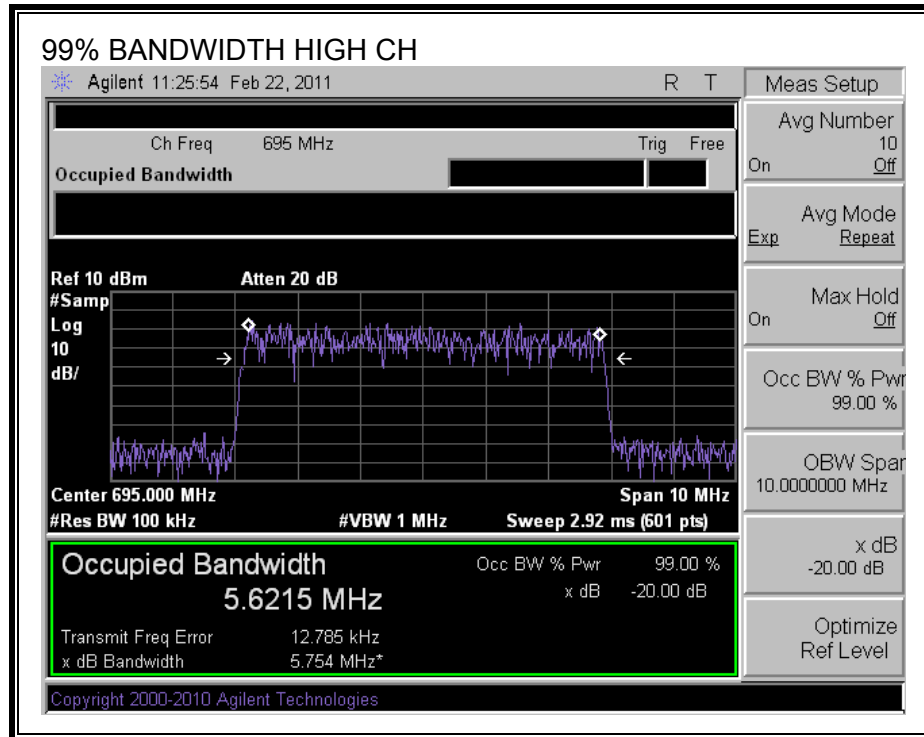
RESULTS

| Channel | Frequency (MHz) | 99% Bandwidth (MHz) |
|---------|--------------------|------------------------|
| Low | 473 | 5.487 |
| Middle | 605 | 5.569 |
| High | 695 | 5.622 |

99% BANDWIDTH







7.2. CONDUCTED AVERAGE OUTPUT POWER

LIMITS

None, for reporting and reference purposes only.

TEST PROCEDURE

The transmitter output is connected to a power meter via a power splitter and 10 dB pad.

RESULTS

| Channel | Frequency (MHz) | Measured Power (dBm) | Path Loss (dB) | Output Power (dBm) |
|---------|--------------------|-------------------------|-------------------|-----------------------|
| Low | 473 | 14.96 | 13.57 | 28.53 |
| Middle | 605 | 15.47 | 13.63 | 29.1 |
| High | 695 | 14.64 | 14.27 | 28.91 |

7.3. ADJACENT CHANNEL EMISSIONS

7.3.1. LIMITS

FCC §15.709 (c) (1) In the television channels immediately adjacent to the channel in which a TVBD is operating, emissions from the TVBD shall be at least 72.8 dB below the highest average power in the TV channel in which the device is operating.

7.3.2. INSTRUMENT SETTINGS

FCC §15.709 (c) (2) Emission measurements in the channel of operation shall be performed using a resolution bandwidth of 6 megahertz with an average detector. Emission measurements in the adjacent channels shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

7.3.3. DESCRIPTION OF TEST PROCEDURE

The signal source (signal generator or EUT, as applicable) is connected to the common port of a power splitter. One splitter output port is connected to a power meter via a fixed attenuator. The other splitter output port is connected to a spectrum analyzer via a step attenuator.

The procedure is designed to yield the maximum possible dynamic range from the spectrum analyzer. The concept is to adjust the step attenuator to ensure that the total peak power at the input mixer of the spectrum analyzer is as close as possible to, but does not exceed, the maximum level for which linear operation is guaranteed.

Power meter and spectrum analyzer measurements are made simultaneously.

First the signal generator is used as the source. The spectrum analyzer RF path loss, with the step attenuator setting adjusted to meet the constraint described above, is measured and used as a correction factor for the raw spectrum analyzer readings. The power meter RF path loss is also measured and used as a correction factor for the raw power meter readings.

Then the EUT is used as the source. The spectrum analyzer instrument settings are adjusted to the values specified for the adjacent channel emissions measurement. The corrected spectrum analyzer reading is subtracted from the corrected power meter reading and this difference is compared to the specification limit.

7.3.4. TEST PROCEDURE AS APPLIED TO PARTICULAR INSTRUMENTATION AND MID CHANNEL OF EUT

The peak-to-average ratio of this EUT is 7 dB. The maximum average power of this EUT is 29 dBm and the maximum peak power of this EUT is 36 dBm. The maximum input mixer level of this spectrum analyzer is -10 dBm for linear operation (Note that this maximum level for linear operation is significantly lower than the guaranteed 1 dB gain compression specification of +3 dBm at the input mixer). Therefore a total path loss (which consists of the external components in the RF path plus the internal attenuation of the spectrum analyzer) of 46 dB is required to optimize the power at the input mixer.

The signal generator was connected to the input of the power splitter. The signal generator is set the CW mode, the frequency is set to 605 MHz, the center frequency of the middle channel under test, and the amplitude is set to +20 dBm. The step attenuator is adjusted to 21 dB and the internal attenuation of the spectrum analyzer is set to 20 dB. The raw reading on the spectrum analyzer is -5.43 dBm. The external RF path loss, hence spectrum analyzer correction factor, is $20 - (-5.43) = 25.43$ dB.

Note that the total path loss to the input mixer is $25.43 + 20 = 45.43$ dB; see discussion below in "TEST PROCEDURE DEVELOPMENT NOTES."

With the same signal generator setup, the raw reading on the power meter, with a 10 dB fixed attenuator in this path, was +6.37 dBm. The RF path loss, hence power meter correction factor, is $20 - 6.37 = 13.63$ dB.

The EUT was then connected to the input of the power splitter.

The average power meter indicated 15.47 dBm, for an EUT power of $15.47 + 13.63 = 29.10$ dBm.

The reverse limit is given by:

$$\begin{aligned} &\text{Average Power} - \text{Specification Limit} - \text{Spectrum Analyzer RF Path Loss} \\ &= 29.1 - 72.8 - 25.7 = -69.4 \text{ dBm} \end{aligned}$$

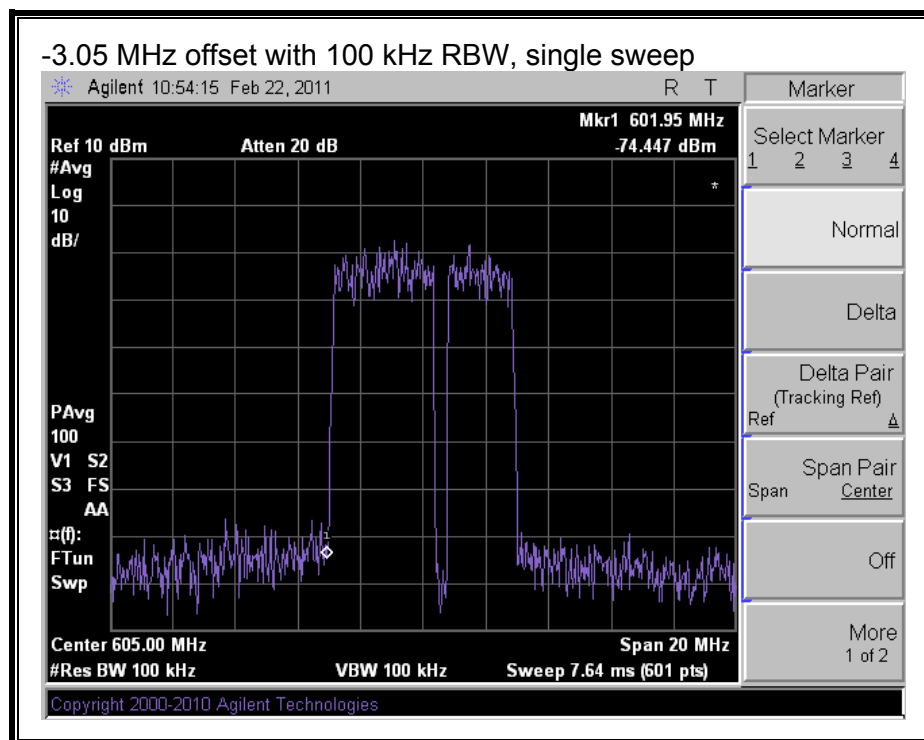
The sideband skirt on the Low side of the EUT signal showed a higher amplitude than the sideband skirt on the High side of the EUT signal, therefore measurements were concentrated on the Low side.

OFFSET = -3.05 MHz

For the specified RBW = 100 kHz, an offset of -3.05 MHz from the channel center frequency places the center of the RBW filter 50 kHz away from the authorized channel edge. This offset yields an absolute frequency of $605 - 3.05 = 601.95$ MHz.

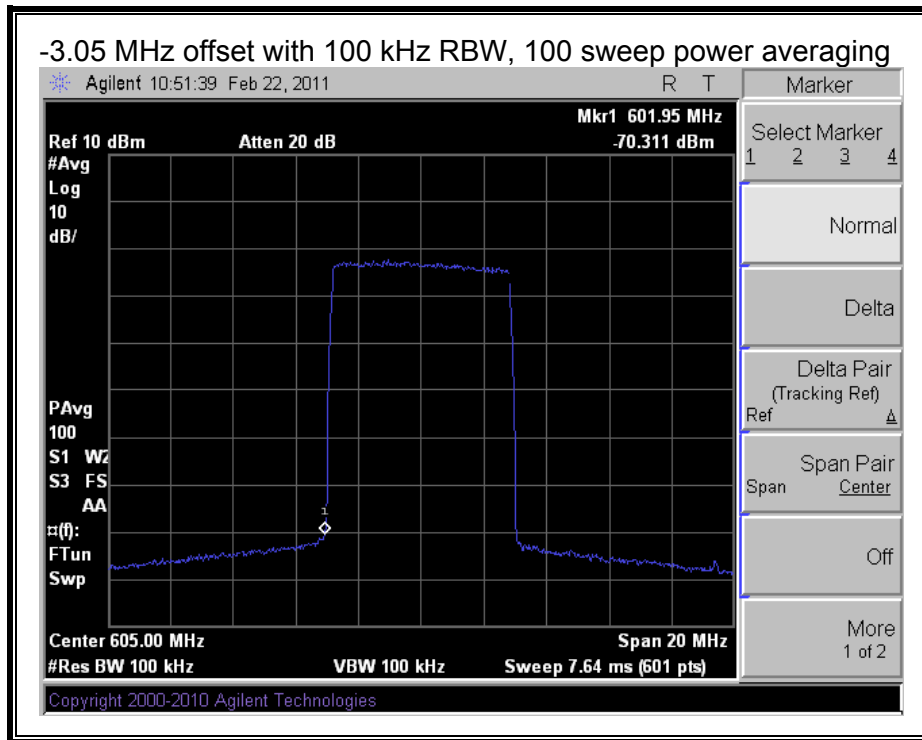
SINGLE SWEEP MEASUREMENTS

With a single sweep, a raw reading of -74.45 dBm was measured, for a margin of 6.05 dB below the limit. We conclude that this particular measurement is artificially low because it does not represent the true average signal level. Other measurements made under the same conditions could be artificially high.



POWER AVERAGED MEASUREMENTS

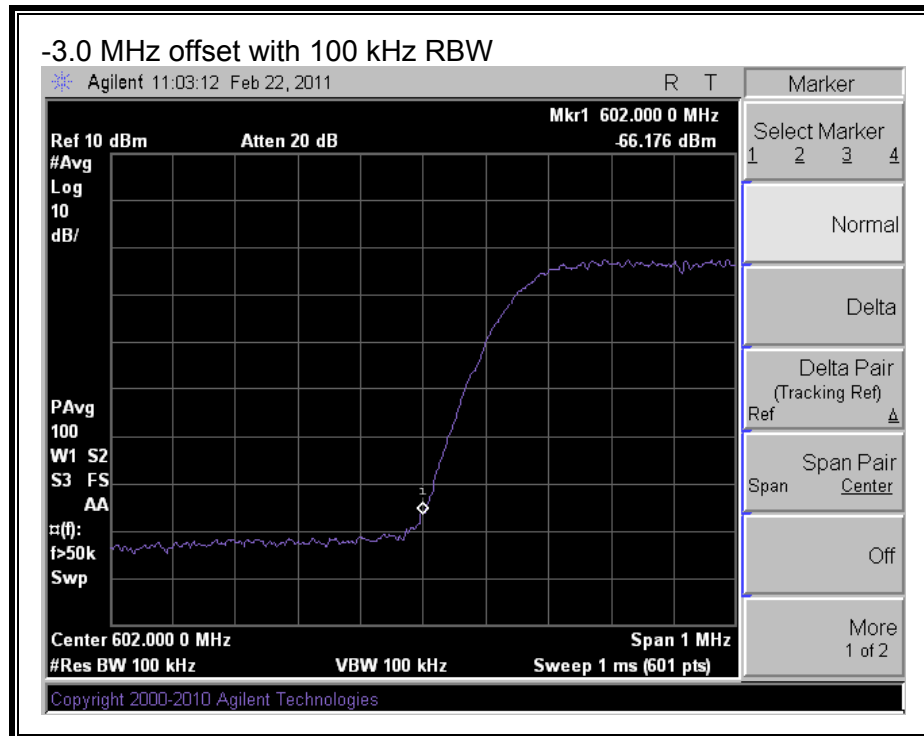
With 100 sweep power averaging, a raw reading of -70.31 dBm was measured, for a margin of 0.91 dB below the limit. We conclude that this measurement is accurate because it yields the true average signal level by computing the RMS average of 100 measurements.



OFFSET = -3.0 MHz WITH 100 kHz RBW

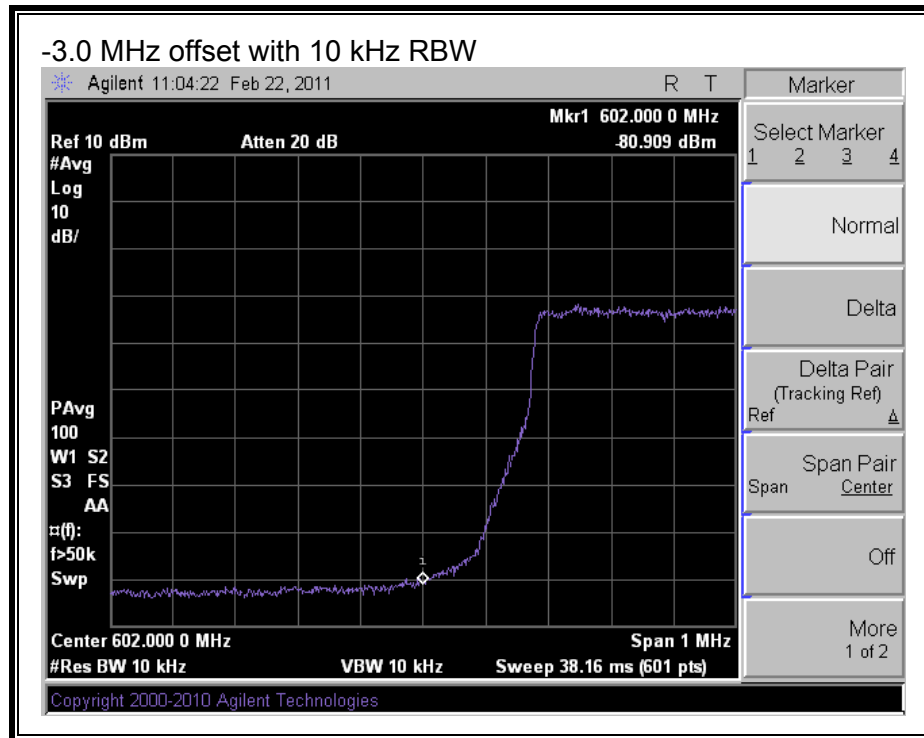
An offset of -3.0 MHz from the channel center frequency places the center of the RBW filter on the authorized channel edge. This offset yields an absolute frequency of $605 - 3.0 = 602$ MHz.

For the specified RBW = 100 kHz, a raw reading of -66.18 dBm was measured, for a margin of 3.22 dB above the limit. It is noted that this measurement includes significant in-band energy.



OFFSET = -3.0 MHz WITH 10 kHz RBW

For an RBW = 10 kHz, a raw reading of -80.91 dBm was measured. Assuming a correction of $10 * \log(100 \text{ kHz} / 10 \text{ kHz}) = 10 \text{ dB}$, this yields an estimated power of -70.91 dBm/100 kHz, for an estimated margin of 1.51 dB below the limit.



We recommend further measurements, and associated discussion, regarding the integration bandwidth for a final certification test. One consideration is to integrate the power from 601.95 to 602.05 MHz, while another is to integrate the power from 601.9 to 602.0 MHz.

To the extent that the slope of the skirt from 601.95 MHz to 602 MHz is the same as the slope from 602 MHz to 602.05 MHz, the first consideration will yield an accurate measurement of the emission density per 100 kHz at 602 MHz.

To the extent that the slope of the skirt from 601.95 MHz to 602 MHz is the shallower than the slope from 602 MHz to 602.05 MHz (note that this is the most likely characteristic), the first consideration will yield a higher-than-actual measurement of the emission density per 100 kHz at 602 MHz.

To the extent that there is any slope of the skirt from 601.9 MHz to 602 MHz, the second consideration will yield a lower-than-actual measurement of the emission density per 100 kHz at 602 MHz.

To the extent that the FCC can interpret the Rule excerpt, "...measured energy is integrated..." to encompass the $10 * \log(\text{RBW} / \text{Specified Measurement BW})$ correction factor, this can also be considered.

7.3.5. TEST PROCEDURE DEVELOPMENT NOTES

Note that the total path loss to the input mixer is $25.43 + 20 = 45.43$ dB, which is 0.6 dB less than the optimum desired value.

At the beginning of this measurement development process we determined, using a CW signal, that the spectrum analyzer IF overload error message came on at a level about 1.5 dB higher than the maximum input mixer linear operating level.

We also determined that the IF overload message tracked with the total power to the input mixer using a modulated signal under test. This was verified by setting the spectrum analyzer such that $RBW > EBW$ ($8 \text{ MHz} > 6 \text{ MHz}$) and selecting peak detector mode. There was more noise associated with this signal, but the same delta of about 1.5 dB between the optimum input mixer level and IF overload was observed.

Therefore we chose to limit our maximum level to 1 dB below the IF overload warning level, as this was easy to determine with a CW signal.

At the conclusion of these measurements we measured the system noise floor and determined that the actual dynamic range is 84.2 dB, which is 11.4 dB below the specification limit. Therefore for a final certification measurement of this device we would adjust the step attenuator to 22 dB to ensure that the input mixer level remained below -10 dBm.

Note that in the 100 kHz measurement bandwidth, the power to the IF is significantly lower than the total power to the input mixer, by a theoretical factor of $10 * \text{Log}(6 \text{ MHz} / 100 \text{ kHz}) = 17.8$ dB.

Also note that there will be a difference between peak detector and average detector, depending on the implementation characteristics of the peak detector.

7.3.6. PRECAUTIONARY NOTE

Since the spectral envelope in a 100 kHz measurement bandwidth is significantly lower than the total power of the EUT, the input mixer power cannot be determined by observing the level of the envelope on the spectrum analyzer display. This is the reason for the multi-step process of setting the external path attenuation to optimize the dynamic range.

7.3.7. HIGH CHANNEL RESULTS

The signal generator was connected to the input of the power splitter. The signal generator is set the CW mode, the frequency is set to 695 MHz, the center frequency of the high channel under test, and the amplitude is set to +20 dBm. The step attenuator is adjusted to 21 dB and the internal attenuation of the spectrum analyzer is set to 20 dB. The raw reading on the spectrum analyzer is -6.14 dBm. The external RF path loss, hence spectrum analyzer correction factor, is $20 - (-6.14) = 26.14$ dB.

With the same signal generator setup, the raw reading on the power meter, with a 10 dB fixed attenuator in this path, was +5.73 dBm. The RF path loss, hence power meter correction factor, is $20 - 5.73 = 14.27$ dB.

The EUT was then connected to the input of the power splitter.

The average power meter indicated 14.64 dBm, for an EUT power of $14.64 + 14.27 = 28.91$ dBm.

The reverse limit is given by:

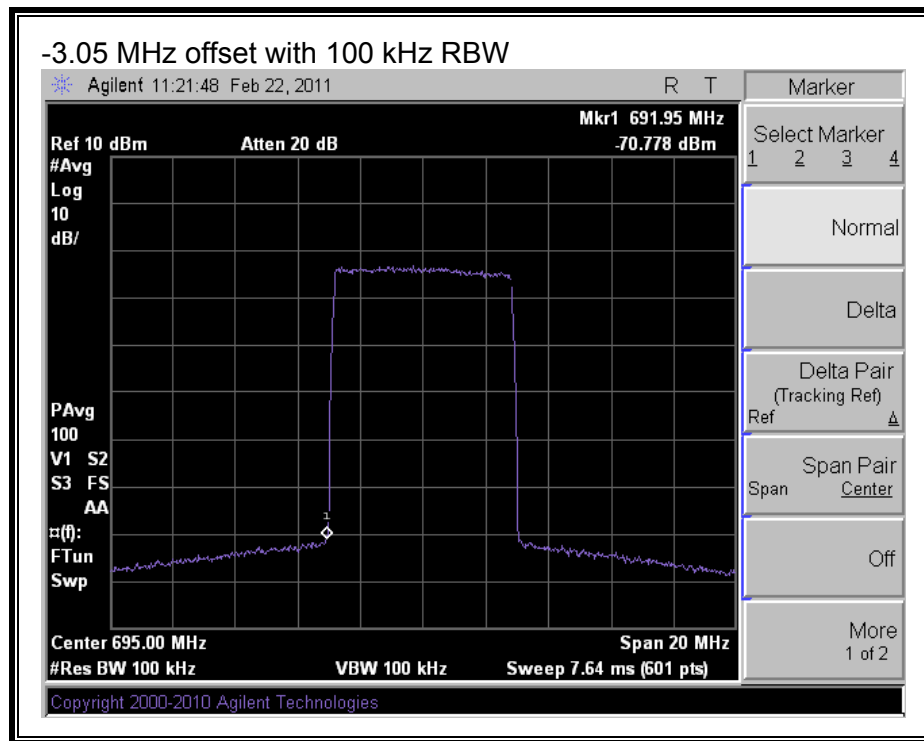
$$\begin{aligned} &\text{Average Power} - \text{Specification Limit} - \text{Spectrum Analyzer RF Path Loss} \\ &= 28.91 - 72.8 - 26.14 = -70.03 \text{ dBm} \end{aligned}$$

The sideband skirt on the Low side of the EUT signal showed a higher amplitude than the sideband skirt on the High side of the EUT signal, therefore measurements were concentrated on the Low side.

OFFSET = -3.05 MHz

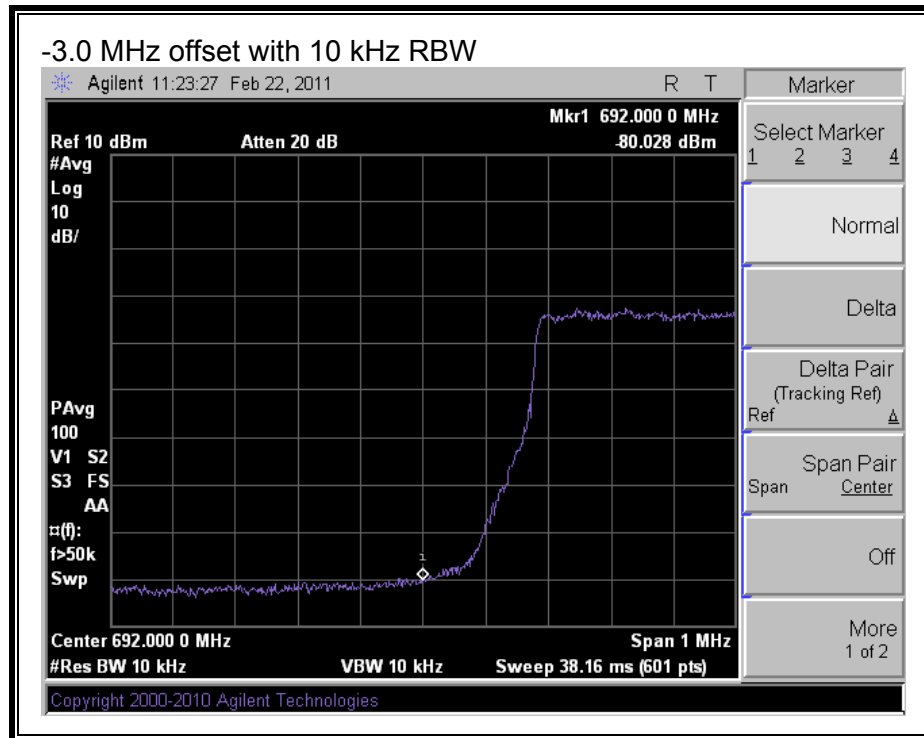
For the specified RBW = 100 kHz, an offset of -3.05 MHz from the channel center frequency places the center of the RBW filter 50 kHz away from the authorized channel edge. This offset yields an absolute frequency of $695 - 3.05 = 691.95$ MHz.

A raw reading of -70.78 dBm was measured, for a margin of 0.75 dB below the limit.



OFFSET = -3.0 MHz WITH 10 kHz RBW

For an RBW = 10 kHz, a raw reading of -80.028 dBm was measured. Assuming a correction of $10 * \log(100 \text{ kHz} / 10 \text{ kHz}) = 10 \text{ dB}$, this yields an estimated power of -70.028 dBm/100 kHz, for an estimated margin of 0.002 dB below the limit.



7.3.8. LOW CHANNEL RESULTS

The signal generator was connected to the input of the power splitter. The signal generator is set the CW mode, the frequency is set to 473 MHz, the center frequency of the high channel under test, and the amplitude is set to +20 dBm. The step attenuator is adjusted to 21 dB and the internal attenuation of the spectrum analyzer is set to 20 dB. The raw reading on the spectrum analyzer is -5.23 dBm. The external RF path loss, hence spectrum analyzer correction factor, is $20 - (-5.23) = 25.23$ dB.

With the same signal generator setup, the raw reading on the power meter, with a 10 dB fixed attenuator in this path, was +6.43 dBm. The RF path loss, hence power meter correction factor, is $20 - 6.43 = 13.57$ dB.

The EUT was then connected to the input of the power splitter.

The average power meter indicated 14.96 dBm, for an EUT power of $14.96 + 13.57 = 28.53$ dBm.

The reverse limit is given by:

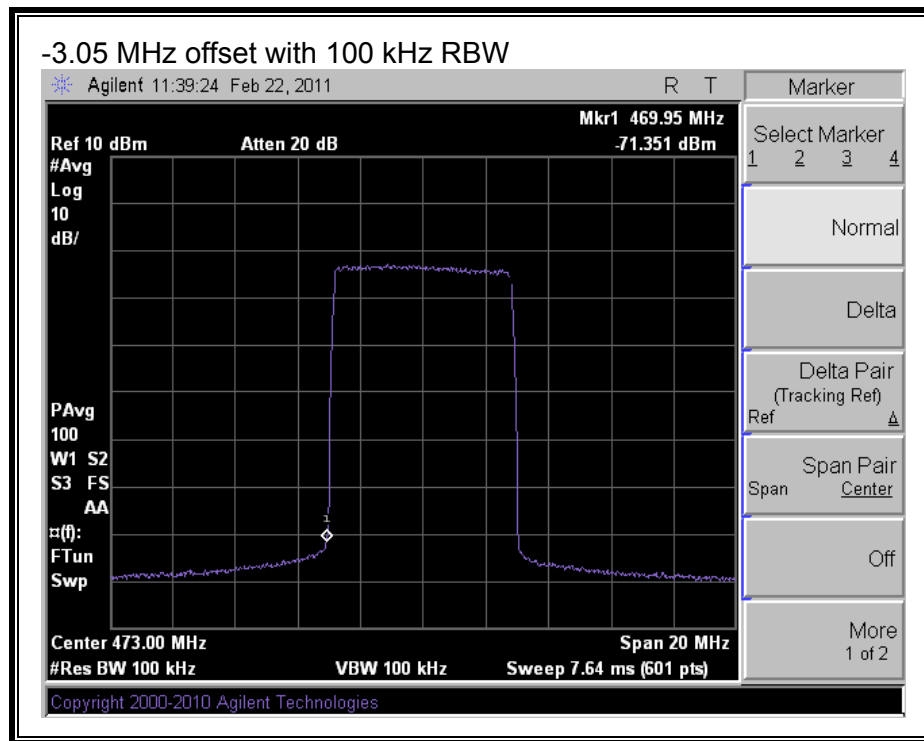
$$\begin{aligned} &\text{Average Power} - \text{Specification Limit} - \text{Spectrum Analyzer RF Path Loss} \\ &= 28.53 - 72.8 - 25.23 = -69.50 \text{ dBm} \end{aligned}$$

The sideband skirt on the Low side of the EUT signal showed a higher amplitude than the sideband skirt on the High side of the EUT signal, therefore measurements were concentrated on the Low side.

OFFSET = -3.05 MHz

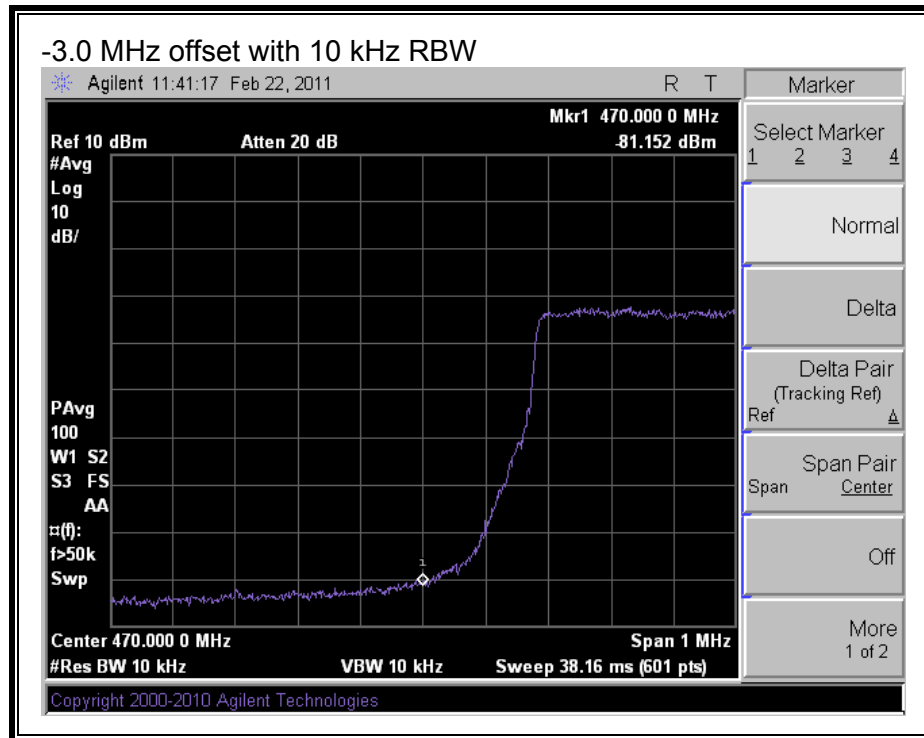
For the specified RBW = 100 kHz, an offset of -3.05 MHz from the channel center frequency places the center of the RBW filter 50 kHz away from the authorized channel edge. This offset yields an absolute frequency of $473 - 3.05 = 469.95$ MHz.

A raw reading of -71.35 dBm was measured, for a margin of 1.85 dB below the limit.



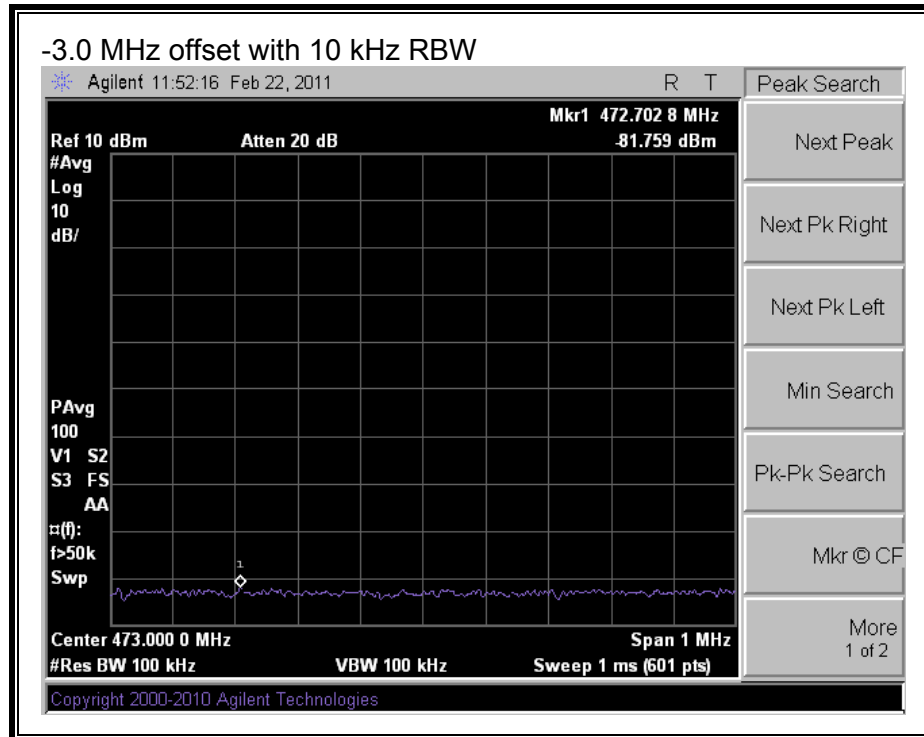
OFFSET = -3.0 MHz WITH 10 kHz RBW

For an RBW = 10 kHz, a raw reading of -81.15 dBm was measured. Assuming a correction of $10 * \log(100 \text{ kHz} / 10 \text{ kHz}) = 10 \text{ dB}$, this yields an estimated power of -71.15 dBm/100 kHz, for an estimated margin of 1.65 dB below the limit.



7.3.9. SYSTEM NOISE FLOOR

For an RBW = 100 kHz, a raw reading of -81.76 dBm was measured, for a system noise floor margin of 12.3 dB below the limit.



END OF REPORT